CVPIA ONLY

Attachment H

Proposal # 2001- F-208 (Office Use only)

A. PSP Cover Sheet

Proposal Title: Sediment and Hg Fate and Transport Models to Guide Monitoring and Management in the Delta

Applicant Name: Larry Walker Associates
Contact Name: Andrew E. Bale
Mailing Address: 509 4th St., Davis, CA 95616
Telephone: (530) 753-6400 X30
Fax (530) 753-7030
Email: AndyB@lwadavis.com

Amount **of** funding requested: $ 392,000
Some entities charge different costs dependent on the *source* of the funds. If it is different for state or federal funds list below.
State cost _____ **Federal** *cost* _____

Cost share partners? X Yes ___ **No**
Identify partners and amount contributed by each Sacramento River Watershed Program: $40,000
Danish Hydraulics Institute: $93.000

Indicate the Topic far which **you** are applying (check **only one box).**

- ☐ Natural Flow Regimes
- ☐ Nonnative Invasive Species
- ☐ Channel Dynamics/Sediment Transport
- ☐ Flood Management
- ☐ Shallow Water Tidal/ Marsh Habitat
- ☒ Contaminants
- ☐ Beyond the Riparian Corridor
- ☐ Local Watershed Stewardship
- ☐ Environmental Education
- ☐ Special Status Species *Surveys* and Studies
- ☐ Fishery Monitoring, Assessment and Research
- ☐ Fish Screens

What county or counties is the project located in? Sacramento, Yolo, Solano, San Joaquin, Contra Costa

What CALFED **ecozone is the project** located in? See attached list and indicate number. Be as specific as **possible** San Joaquin-Sacramento Delta

Indicate the type *of* applicant (check only one **box):**

- ☐ State agency
- ☐ Public/Non-profit joint venture
- ☐ Local government/district
- ☐ University
- ☐ Other: _____
- ☐ Federal agency
- ☐ Non-profit
- ☐ Tribes
- ☒ Private party

B. Executive Summary

Title: Sediment and Hg Fate and Transport Models to Guide Monitoring and Management Plans in the Delta.

Amount requested $392,000

Contact: Andrew E. Bale, Ph.D.
Lany Walker Associates, 509 4" Street, Davis, CA. 95616
Phone: (530) 753-6400 x30; Fax: (530) 753-7030; Email: andyb@lwadavis.com

In collaboration with:
Danish Hydraulics Institute, and CalFed Grants #99-B06, #97-BO2, and #97-CO5

The proposed project is a research project with the general objective of establishing a science-based modeling approach to support adaptive management of Hg contamination in the Sacramento-San Joaquin Delta Specifically, the project will simulate sediment and Hg distributions in the Delta, link simulated MeHg concentrations to fish burdens, and estimate relative effects of management plans. Models developed under this project will guide Hg monitoring plans and assess mitigation schemes and wetland construction plans.

To achieve these objectives, the project will develop models to simulate Delta hydrodynamics and sediment transport. Into these models, a set of Hg transformations will be incorporated to estimate MeHg exposure levels throughout the Delta. Additionally, simple Hg speciation and biouptake models will be developed to estimate fish tissue Hg levels at representative locations. Alternative management plans will define simulation scenarios, and results of these scenarios will be compared to evaluate plans. *All* models will be calibrated to available field data.

Several hypotheses may be evaluated using the proposed models of Hg transport, transformation and uptake. Among these hypotheses are:

1). Achievable levels of cleanup in the Cache Creek watershed will have a significant impact on fish and wildlife Hg exposure in the Delta.

2). Location of wetlands in the Delta is an important factor in minimizing exposure to Hg.

3). On an annual basis, most Hg transported to the Delta does not remain in the Delta and has little effect on wildlife exposure to MeHg.

The great uncertainty in developing a Hg monitoring plan or establishing Hg management schemes lies in the connection between Hg sources and exposure levels. Once in the Delta, Hg from all sources is mixed and moved in complex patterns governed by tides, tributary flows, and Delta channel configuration. The proposed project addresses this uncertainty through use of numerical models that approximate Delta currents and sediment distribution.

The proposed project expects to establish the foundation for a better understanding of the significance of Hg sources and impacts of structural change (including wetland construction) on Hg exposure in the Delta. The models will be an integral part of an adaptive management approach involving iterative refinement of conceptual models, monitoring plans, and numerical models. The overall goal of such a plan is to improve and maintain the quality of Delta water and sediments and eliminate toxic impacts on organisms.

C. Project description

C.1. Statement **of** Problem

C.1a. Problem description. Levels of Hg in the Delta pose wildlife and human health hazards. Recent sampling demonstrates that MeHg concentrations in several popular sport fish within San Francisco Bay and the Sacramento-San Joaquin Delta areas exceed both human health and wildlife health safety criteria (Fairey et al. 1997, **SFEI** 1999). Typically, these high levels of MeHg are the results of food chain bioaccumulation and magnification (Keating 1997). The single most important factor in Hg bioaccumulation is level of organism exposure to dissolved MeHg. But MeHg concentrations may vary significantly throughout the Delta and in time, making fish and wildlife exposure difficult to estimate using observed data alone.

To reduce or eliminate toxic levels of exposure, Hg monitoring and management plans should be developed in an adaptive management approach that includes numerical models. While Hg monitoring and lab research are heavily funded under CalFed Directed Action #99-B06 (Stephenson et al 1999), true adaptive management for Hg requires the implementation of numerical models in conjunction with monitoring and lab research. Such numerical models were highly recommended by the scientific committee that reviewed the current CalFed Hg project.

Estimating MeHg exposure is complicated by uncertainty about the size and nature of potential Hg sources and by the complexity of Delta hydrodynamics. Because different sources may exhibit different bioavailability, local methylation rates may depend on the origin of Hg that supplies the methylation process. It should therefore be necessary to quantify the relative contributions of Hg from different sources at any site of concern.

In the Delta, local MeHg concentrations may, depend on local methylation rates as much as on transport from distant sites. Relatively large loads of Hg and MeHg are transported from throughout Central Valley watersheds to the Sacramento-San Joaquin Delta each year. But research in Lavaca Bay and elsewhere indicates that historic deposits of sediment-bound Hg have the potential to produce significant amounts of MeHg, and sediment fluxes of MeHg may equal or dwarf annual external loads (Gill et al. 1999). Furthermore, currents in the Delta may transport MeHg produced in Delta "hot spots" to other locations.

Adding to uncertainty about MeHg exposure are the complexities of the aquatic Hg cycle, including transformations, speciation, and biouptake. Hg cycling plays an important role in determining exposure and has been the subject of several modeling studies. Very detailed models of Hg cycling have been developed (Martin 1992, Hudson 1994, and Bale 1995) and applied (PTI 1997, Arizona 1999, Bale 2000), but such models **are** generally limited in their application to the Delta by two considerations. First, there are generally not the data to justify such detail in application. Second, all of these models have been applied to lakes, and most do not consider hydrodynamic transport, an important consideration in the Delta.

Because of the importance of location and hydrodynamic transport, and because of the long-term nature of assessing change in contamination and exposure, a simulation of Delta Hg fate and transport requires a relatively sophisticated model capable of both temporal and spatial detail. This project proposes to develop numerical models to simulate Delta hydrodynamics, sediment and Hg transport, MeHg production, and biouptake. The models will produce daily, monthly and seasonal estimates of sediment and water column concentrations of both dissolved and total Hg and MeHg. The models will explicitly link Hg sources in and around the Delta to fish and wildlife exposure and will estimate fish tissue levels of Hg under various management scenarios. Such links will allow managers to estimate Hg load reductions required to bring fish tissue levels of Hg in the Delta to targeted levels.

C.1b. Conceptual Model. The connection between Hg loads and resultant levels of fish and wildlife contamination in the Delta is complex. There are many potential sources of Hg

and many bio-geochemical transformation that affect the fate and bioavailability of Hg in the Delta environment.

Generally, Hg is delivered to the Delta by direct discharges, tributary inflow, exchange with sediments, or atmospheric deposition. Hg in the water column is transported throughout the Delta, primarily attached to fine suspended sediments in water. Some fraction of water column Hg may be reduced to elemental form and volatilize. When the water reaches areas of low energy or quiescence, sediments are deposited and both Hg and sediments become a part of the surficial sediment bed. Biological activity near the anoxic-oxic interface of the sediment bed produces MeHg at rates that depend upon ambient conditions. The MeHg produced by benthic methylation disperses into overlying waters and may be transported throughout the Delta where it is available for uptake by organisms. In animals higher on the food chain, like predatory sports fish and birds, Hg may be magnified to potentially dangerous levels resulting in health hazards, consumption warnings, and take restrictions. The overall structure of this conceptual model has four distinct components including sediment and Hg transport, Hg cycling, speciation, and biouptake as shown in

Figure 1 and described below.

Transuort. Upon arrival at the Delta, waters of its many tributaries spread out in the Delta's network of channels and mix with water from the Bay. The hydrology of the watershed is typified by an annual cycle of large winter and early spring flows followed by much smaller summer base flows. Waters from throughout the watershed generally flow quickly and directly to the Delta, but movement of water in the Delta is complicated by tidal influences and the Delta's complex channel network. Tidal flows, imposed at the western outlet of the Delta, are typified by a 25-hour repeating cycle superimposed upon longer (e.g. 19-year) cycles of highs and lows. Tidal flood in opposition to tributary flow can drive river water into the far reaches of the Delta network. These complicated flow patterns govern the movement and distribution of contaminants and create a continually changing aquatic environment in the Delta.

Cycling of Hg. The fate, or cycling, model proposed for this study is depicted in Figure 2. In this conceptual model, the Delta is represented as a set of volumes linked by hydrodynamics. A typical volume, or aquatic cell, is represented by an aquatic element and a benthic element immediately below. The benthic element represents the very shallow biologically active layer of surficial sediments. Within both the water column and the active sediment bed, biochemical reactions (e.g. reduction and net methylation) transform Hg between its three commonly measured species (reactive HgII, elemental Hg^0, and MeHg). The set of transformations included in this model represent significant processes that may be estimated, by either literature review, current field studies, or calibration, to a first approximation. Both reactive HgII and MeHg are present in different forms including dissolved, particulate-bound, and biochemically-available fractions. Physical processes such as deposition, erosion, diffusion, and burial serve to transport Hg between air, water, benthos, and deep sediments.

The model accounts for several sources of Hg to a typical aquatic "cell." These sources include atmospheric deposition and diffusion, watershed runoff, advection and diffusion from another aquatic element, and point sources.. Potential losses of Hg from an aquatic cell come from advection and diffusion to another aquatic cell, burial to deep sediments, and volatilization. Point sources may include wastewater treatment plants, agricultural returns, mine drainage, or thermal springs.

Soeciation of HE. As it is transported within the watershed, Hg species undergo transformations and form compounds with other chemical components of the aquatic environment including chlorine, hydroxide, sulfide, and organic material. The types of compounds that Hg forms can influence the availability of Hg for bio-geochemical reactions and thereby govern the cycling of mercury between species. As a first approximation, species

of Hg may be determined at representative locations in the Delta by applying chemical equilibria models to observed or assumed concentrations of dominant water chemistry constituents.

Hg trouhic transfer. Nearly all Hg found in fish and wildlife is MeHg, a species of Hg derived from methylation of HgII compounds, and toxic amounts are generally found only high on the food chain. A simplified version of Hg trophic transfer is depicted in Figure 3.

Fish tissue Hg concentrations can be estimated as a function of water chemistry and phytoplankton characteristics. The major enrichment step for Hg occurs at the bottom of the food chain where phytoplankton can concentrate Hg to levels 10^3-10^5 times background water concentrations. Biomagnification above phytoplankton may increase Hg levels by factors of 10-10^2 times. Because phytoplankton enrichment is such an important step in Hg trophic transfer, Hg biomagnification may be modeled to a first approximation by modeling phytoplanktonenrichment and applying a biomagnification factor after that. This model of phytoplankton enrichment and biomagnification was proposed by Mason et al. (1996). Conceptually, the model assumes water chemistry (pH and salinity) and phytoplankton size and growth rate will determine the degree to which MeHg will diffuse into phytoplankton. Fish Hg levels are described as a linear function of MeHg octanol-water partition coefficient, MeHg concentration, and the inverse product of phytoplankton size and growth rate. For some species, benthic uptake routes are important and this uptake may be modeled with similar equations (Mason 2000).

C.1c. Hypotheses being tested. The proposed study is being developed to address the CalFed goal to "improve and maintain water and sediment quality to eliminate, to the extent possible, toxic impacts on organisms in the system, including humans," specifically in the Sacramento-San Joaquin Delta. Effective management of water and sediment quality to protect organisms can only occur when the links between manageable sources of toxic contamination and toxic exposure are understood.

There are a great many uncertainties inherent in establishing such links between sources, exposure, and tissue burdens. But the establishment of a modeling scheme, with models calibrated and validated to observation, will allow for a systematic identification and evaluation of those uncertainties and their relative significance. For instance, restoration projects may be subject to different types, different timing, and different quantities of contaminant loading depending upon their location in the Delta. This project will quantify these uncertainties within well-defined ranges.

A great deal of knowledge about the Delta supports such a study. Delta morphology and hydrodynamics are relatively well characterized from decades of measurement and modeling by government agencies and municipalities. Sediment transport has a well-established body of knowledge and has been, and is currently being, studied in the Delta. Knowledge of Hg cycling, a focus of this study's investigations, has benefited from a great deal of scientific inquiry in recent years. Organized within the framework of a modeling scheme, all of this information can help to clarify, define, and evaluate uncertainties that inhibit the development of effective monitoring programs and management schemes.

Some of the key hypotheses that will be addressed by this study include questions about location of restoration projects and the effectiveness of long-term source reduction. Among others, the study will address these hypotheses:

1). Achievable levels of cleanup in the Cache Creek watershed will have a significant impact on fish and wildlife Hg exposure in the Delta.

2). Location of wetlands in the Delta is an important factor in minimizing exposure to Hg.

3). On an annual basis, most Hg transported to the Delta does not remain in the Delta and has little effect on wildlife exposure to MeHg.

C.1d. Adaptive Management. This project is a strong first step in the adaptive management approach to Hg toxicity and exposure in the Bay-Delta environment. The project brings considerable knowledge about Delta circulation, sediment transport, and Hg cycling to build a set of numerical models that will address questions about the distribution of Hg-contaminated material and the degree and timing of Hg exposure in the Delta. In collaboration with CalFed Grant #99-BO6, the models will be used to identify significant data gaps in our current knowledge and will provide initial estimates of the effectiveness of management programs and the potential for structural changes, like wetland restoration, to affect toxic exposure.

Such questions cannot be fully and effectively addressed by field studies alone, principally because the scope of necessary studies would be too great. Estimating the extent of exposure through a diverse ecosystem like the Bay-Delta from field study alone might entail sampling hundreds of stations periodically over years of time. Similarly, quantifying the effects of management plans on toxic exposure of a bioaccumulated contaminant would take decades of study. Models allow extrapolation, or interpolation, of a small data set to an entire ecosystem over long periods of time. These extrapolations are carefully bounded because the models are based on well-developed science and "truthed" to the observed data used in calibration and validation.

As part of the adaptive management scheme, it is important to develop numerical models early in the process of data collection and management plan development. In this project, current knowledge will be used to develop numerical models that will then be applied to identify data gaps and inconsistencies. Monitoring studies will incorporate this information to fill data gaps, and the data from these studies will be used to refine the models throughout the iterative process of adaptive management.

C.2. Proposed Scope of Work

C.2a. Geographic Boundaries of the Project. The proposed study will model hydrodynamics, sediment transport, and Hg cycling and transport within the Sacramento-San Joaquin Delta Ecological Region. The area of study will include parts of Sacramento, Yolo, Solano, Contra Costa, San Joaquin, may include parts of Alameda and Stanislaus Counties, and will lie approximately between latitudes 38°30' and 37°37'30'' and longitudes 122°00' and 121°15'. A map of the study area is shown in Figure 4.

C.2b. Approach

The overall objective of this proposal is to establish a set of numerical models as part of adaptive Hg management for the Sacramento-San Joaquin Delta. Specific objectives of this project are to:

1. Simulate the distribution of sediments and Hg from external and internal sources to locations within the Delta:
2. Identify areas of potentially high Hg methylation and toxic exposure.
3. Establish a link between simulated MeHg concentrations and fish tissue Hg concentrations.
4. Estimate the effects of source reduction and structural change in the Delta on levels of toxic Hg exposure.

The first step towards setting up models of the Delta is discretization, the division of Delta channels into small discrete reaches. The Delta will be discretized in detail with about 500 reaches, representing channels as small as about 300 meters in length and 7 meters in width. In water quality modeling, these reaches represent an interconnected series of compartments with water column and benthic elements that are completely mixed during each time step, This channel geometry will be adapted from Department of Water Resources' DSM2 model input.

Based on this channel description, a hydrodynamic model will be set up to describe flow patterns in the Delta. For the general nature of this investigation, a one-dimensional

representation of the Delta's complex channel system, including main channels and backwater sloughs, is considered sufficient. A two-dimensional wetland model will be considered for simulation of flooded lands. The models will be built on existing modeling frameworks that describe fully dynamic hydrodynamics by solving a form of the shallow water equations. Hydrodynamic modeling will produce a description of the complex flow regime of the Delta in response to tides and tributary inflow. Water surface elevation, estimated channel roughness, and flow information used to set up, calibrated, and validated the models will be acquired through the Department of Water Resources and San Francisco Bay-Delta Modeling Forum. Time steps for this modeling will be short (i.e. < 1 hour) to capture the dynamic nature of Delta currents. To produce current regimes that include varying tidal and hydrologic boundary conditions, the model will be run for durations of 1 year or more.

The currents described in this first step will be used to simulate transport of sediments and Hg within the Delta in a standard water quality model that solves the advection-diffusion equation with transformations contributing to source-sink terms in the equation (Bale 2000). Cohesive sediment transport routines will describe the deposition and resuspension of fine sediments as they are carried throughout the system. Suspended sediment concentrations will be calibrated to data collected in CalFed Grant #97-BO2 (Schoelhammer and Dinehart 1997). Estimates of Hg and MeHg partitioning will determined from literature, and sediment concentrations of these contaminants will be calibrated to data collected under CalFed Grants #99-BO6 and #97-C05 and other studies. Model parameters such as particle size and settling rates will be taken from existing and currently collected data. Assuming that sediment concentrations from different sources may be superimposed, the model will track sediments from various sources through the Delta to produce a map of sediments and Hg distribution within the Delta.

Once an initial estimate of the distribution of sediments and Hg in the Delta has been made, a simplified set of Hg cycling routines will be applied dynamically within the water quality model at time steps of between 1 hour and 1 day. These routines will use available information from other studies and values calibrated by mass balance to estimate transformation rates in a fashion similar to that employed at Clear Lake (Bale 2000). Simulated rates of methylation for different Delta environments (e.g. deep channel, channel margins, backwater, and wetlands) will be calibrated to rates determined by current CalFed Hg studies, and will be used to estimate localized MeHg loads (e.g. from wetlands). Simulated currents will determine the relative long-range effects of local loads on MeHg concentrations throughout the Delta.

After establishing a dynamic flow regime and estimates of MeHg concentrations throughout the Delta, a few representative locations will be chosen at which to apply simulations of Hg speciation and resultant biouptake. Speciation will be determined using chemical equilibrium equations, the EPA's MINTEQ model (Brown 1987), or equivalent. Biouptake will be estimated using models proposed by Mason. Fish levels of Hg resulting from water column uptake are described as a linear function of MeHg octanol-water partition coefficient, MeHg concentration, and the inverse product of phytoplankton size and growth rate. Similar equations describe benthic uptake of MeHg (Mason 2000).

Together, these several models establish a link between Hg sources and fish levels of Hg in the Delta. Conceptually, the link is clear but results of this initial modeling effort must be considered first approximations. As true to the idea of adaptive management, the modeling effort itself will suggest areas of refinement and data needs.

Effects of source reductions and management decisions within the Delta will be estimated by applying the models under sets of differing scenarios over time periods of up to 100 years. Hypotheses will be tested by comparing results from at least two scenarios representing negative and positive hypothesis conditions. For example, MeHg concentrations from a no-action scenario will be compared to those from a scenario describing significant cleanup of Hg sources in the Cache Creek watershed. Parameter uncertainty will be estimated through sensitivity analyses.

C.2d. Data Handling and Storage. Although no field data will be collected for this initial modeling project, data will be gathered from all available sources. This data will include extensive channel geometry data describing the Delta, hydrologic information, characteristics of Delta sediments, Hg cycling parameters, water chemistry, and concentrations of suspended sediments and both total and MeHg within the Delta and in source loads. These data will be stored in a specific modeling database that may be in either Excel spreadsheet or Access format. Associated metadata will document data source and reliability where appropriate.

C.2e. Expected Products/Outcomes. The proposed study will produce a set of three reports describing results of each modeling phase and an overall project report. Each report will detail background, modeling approach, and results through text, graphs, and maps. Additionally, results of dynamic simulations will be available as animation files for viewing on a PC. Numerical routines developed for this project in both computer code and Excel spreadsheets will be documented and made publicly available for incorporation into other modeling schemes as desired. Results of this study will provide a foundation for continued modeling studies of the Delta and essential support for related modeling proposed for the San Francisco Bay and the Sacramento River watershed. The study will also provide a basis for modeling the fate and transport of other sediment-associatedpollutants like OC pesticides.

Study results will be presented periodically to members of both collaborating CalFed studies and affected stakeholders and regulatory groups. Results will be submitted for presentation at local forums including North California SETAC, Bay-Delta Modeling Forum, Delta Tributaries Mercury Council, San Francisco Bay Mercury Council, Sacramento River Watershed Program, and appropriate CalFed venues. Additionally, the project will present results **to** the Central Valley and San Francisco Regional Water Quality Boards both of which will work collaborate with this project. National and international forums for presentation of results will be considered based on **funding** available.

C.2f. Work Schedule. The project will run for 2 years, beginning February 2001 and ending December 2002. The project is divided into three separate tasks in order of priority to project objectives. Task 1, construction and application of hydrodynamic and Hg and sediment transport modeling, lasts for 1 year and must be funded for successful completion of this project. Tasks 2 and **3,** Hg speciation and biouptake modeling, takes up the remaining year and may be funded as incremental options. These latter tow tasks could be undertaken contingent on satisfactory completion of Task 1. ***An*** annual timeline showing start-stop times of milestones is shown in Figure 5.

Constructing and applying a sediment and Hg transport model is perceived to be of highest priority because establishing the link between remote sources and contamination of specific locations within the Delta can only be made with such a model. The completion of this task will produce estimates of MeHg exposure within the Delta. The second half of this project applies speciation and biouptake models using Hg concentrations simulated in Task **1.** The resulting estimates of fish tissue Hg will be important in evaluating long-term effects of control strategies, management plans, and structural changes in the Delta. Finally, the overall project will be summarized in a project summary report. This report will discuss the success of the overall modeling report and make recommendations for future research and data collection.

C.2g. Feasibility. This project will not require the issuance of any permits or agreements. The project's successful completion depends upon the construction of a set of numerical models, each of which have been previously constructed either for the Delta or for other aquatic systems.

The first phase of this project entails the development of a hydrodynamic and sediment transport model for the Delta. Several hydrodynamic models have been constructed and successfully applied to the Delta (DWR 1997, RMA 1999), and results of these applications are readily available to help set up this model. Sediment transport routines have not been applied to the Delta as yet, but such routines are in common use and have been developed for the

adjacent San Francisco Bay area (Krone 1992). Field research on sediment transport continues in the Delta (Schoelhammer and Dinehart 1999) and this project will coordinate with that research.

Hg is strongly associated with sediments and, to a first approximation, a constant fraction of total Hg in the water column may be considered bound to sediments (Bale 1995). Using this simple model, both total Hg and MeHg may be tracked along with sediments. Applied with available field data for calibration, such a model of Hg transport is feasible and will yield reasonable results.

Hg transformations have been applied with some success (Bale 2000, PTI 1997). Methylation rates have been estimated for several environments and, in a current CalFed project (Stephenson et al 1999), will be measured for a number of different areas in the Delta. Reduction rates are not as well defined, but this is not a crucial aspect of the model and estimates have been made and applied in similar areas (Mason et al 1993). Volatilization of Hg from the water column will be modeled by a Fickian-type diffusion model. Modeling of these transformations is feasible, but results must be considered as fist approximations.

The proposed models of Hg speciation and biouptake have also been applied and validated. Chemical speciation models have been reliably used, **are** well documented, and should be dependable to the accuracy appropriate in these analyses. The proposed biouptake model has not been widely **used** but it has reasonable scientific basis and will be calibrated to available data. As with other Hg-related information, fish tissue data has been collected, and is continuing to be collected, for the Delta through CalFed and other programs. All in all, this project is feasible and should produce a useful tool for understanding and managing Hg exposure in the Delta.

D. Applicability

D.1. ERP goals and CVPIA priorities. This project addresses the CalFed goal to "improve and maintain water and sediment quality to eliminate, the extent possible, toxic impacts on organisms in the system, including humans." Specifically, this modeling project addresses the uncertainties associated with assessing toxic Hg exposure in the Delta under current and proposed future conditions. Because MeHg is a potent neurotoxin, the young of all species may potentially be harmed by exposure to it. Because of MeHg's ability to bioaccumulate and magnify up the food chain, species particularly affected by management decisions that will be based on this modeling work include (but are not limited to) humans, striped bass, waterfowl and shorebirds, and migratory birds.

The project will produce a modeling tool that will be a necessary component of the ERPs stated desire for an adaptive management approach. The models developed will allow managers and analysts to take a systematic approach to identifying potential Hg toxic "hot spots" of exposure. The models will help to guide effective data collection, and will produce estimates of exposure levels under different managerial scenarios. Using these tools, sampling plans with the most potential for characterizing the complex Delta environment and management plans with the most potential for improving water quality and reducing toxic exposure can be identified, analyzed, and implemented. Also, the models will help to evaluate the potential of management plans that include structural changes l i e wetland construction to increase toxic Hg exposure. Such a modeling framework can form the foundation for more detailed Hg modeling investigation as well as investigations of other sediment-bound contaminants in the Delta and within the Bay-Delta watershed.

D.2. Relationship to other ecosystem restoration projects.

Both Hg-related and sediment transport research projects currently funded by CalFed have agreed to collaborate with this study. These studies are CalFed #99-B06, "Assessment of Ecological and Human Health Impacts of Mercury in the Bay-Delta Watershed" (Stephenson et al 1999), CalFed #97-B02, "Sedimentation in the Delta" (Schoelhammer and Dinehart 1997), and CalFed #97-C05, "Effects of Wetland Restoration on the Production of Methyl Mercury in the San Francisco Bay-Delta System" (Suchanek and Slotton 1997). The assessment focuses on monitoring efforts and laboratory studies to determine Hg loads to the Delta, concentration levels within the Delta, and estimates of Hg bioavailability. Reviewers of that monitoring project strongly recommended that a significant modeling program be developed to tie together the disparate studies within the project and to form an analytic framework within which to use data collected. This modeling project would collaborate with the Hg assessment project to provide these missing links.

Additionally, this modeling study will collaborate with the sedimentation and the methylation studies. Data from the sedimentation study will be used to calibrate these modeling studies. The modeling studies will provide insight into overall sediment transport processes in the Delta and help to guide future directions of the multi-year sedimentation study. Similarly, the modeling project will use data and help guide future sampling in the methylation study.

In addition to supporting these three components of the current ERP, the models proposed in this study will also provide support for decisions about placement of wetland construction projects. Because Hg methylation may depend upon Hg delivery, the source of Hg delivered, and local environmental conditions, it seems essential to simulate the transport of Hg from sources to potential wetland sites under varying hydrologic and morphologic conditions. This project will provide a framework for evaluating management decisions regarding the impacts of wetland construction on Hg exposure in the Delta.

D.5. System-wide ecosystem benefits. Because this modeling project will be a key link in modeling the fate and transport of Hg throughout the Bay-Delta watershed, its benefits will be system-wide. Modeling techniques and analysis can be applied throughout the system,

models developed for the Bay and the upstream watershed can be linked to this effort, and results of this modeling effort will affect decisions both upstream and down.

Significant among programs that expect to benefit from this study are EPA's Clear Lake Superfund site project, San Francisco Estuary Institute's Regional Monitoring Program, and the Sacramento River Watershed Program. Additionally, the development and application of these models will support both the Central Valley and San Francisco Bay Area Regional Water Quality Control Boards in their efforts to produce Hg management plans in the form of TMDLs. Proposed implementation of the recent Hg TMDL for SF Bay will rely heavily on the same kind of modeling proposed for this project. Staff from both of these regional boards will collaborate with this proposed study, and both TMDL coordinators for these boards support this effort (Karkowski 2000, Abu-Saba 2000).

Because it is a modeling exercise and relies heavily on conceptualization, current science, and collected data, this project can serve as a strong link between the many Hg-related studies and planning efforts currently underway and proposed for the Bay-Delta watershed. Because the entire aquatic system of the watershed is connected from sources of the San Joaquin and Sacramento Rivers to the Golden Gate Bridge, this Delta modeling project will be an important first step in linking Hg sources and exposure throughout the ecosystem. Such a link will have clear benefits for the entire ecosystem and especially for the San Francisco Bay Area to which the Delta delivers much of its Hg load.

E. Organization and Qualifications

The overall project will be guided both by collaboration with other CalFed project teams (CalFed #99-BO6, #97-BO2, and #97-CO5) and by a group of technical advisors local, regulatory, and scientific expertise. Andrew Bale of Larry Walker Associates will manage this project. Dr. Bale will be responsible for the completion of each project task. Staff at Larry Walker Associates will handle administration of the grant. Data compilation and organization will be the primary responsibility of Brian Laurenson and Jon Ingersoll of Larry Walker Associates. While Dr. Bale will direct the modeling efforts, Jan Ronberg of the Danish Hydraulics Institute will handle technical aspects of hydrodynamics and sediment fate modeling. Dr. Bale will supervise construction of all Hg-related modeling routines and will guide the analyses and report preparation. No problems are foreseen in connection with the proposed timeline. An organizational chart for the project is presented in Figure 6.

Individual Qualifications

Andrew Bale, principal investigator. Andrew Bale holds a Ph.D. in Civil and Environmental Engineering from the University of California at Davis with an emphasis on water quality modeling and management. Dr. Bale has a detailed knowledge of the physical processes involved in aquatic mercury cycling, uptake by organisms, and bioaccumulation. As a Ph.D. researcher, he developed a model of Hg fate and transport within aquatic ecosystems, and in post-doctoral research developed a model of mercury uptake and bioaccumulation in the aquatic food chain (Bale 1995, Bale 1997, Bale 2000). He was a speaker at the Third International Conferences on Mercury as a Global Pollutant, presenting research focussed on his work at Clear Lake, CA. Currently Dr. Bale is the Hg modeling coordinator for the Sacramento River Watershed Program.

Danish Hydraulics Institute (DHI), collaborators.

DHI Water & Environment is an independent, self-governing research and consultant organization affiliated with the Danish Academy of Technical Sciences. The Institute specializes in the development and dissemination of knowledge and technologies regarding ecology and environmental chemistry, water resources, hydraulic structures and hydrodynamics and related areas. Over the years, DHI has conducted both extensive R&D and consulting projects within the combined field of current and wave induced sediment and contaminant transport. Recent sediment transport studies completed by the DHI include investigations of the impact on circulation and sedimentation patterns from reclamation works in Singapore, investigation of heavy metal pollution from windmills in Denmark, and hydraulics, sediment and heavy metal fate and transport modeling in Haifa, Israel.

Four members of the Institute are likely collaborators on this project. Arne Jensen is a senior engineer with national and international experience in industrial heavy metals contamination, especially cadmium and mercury (Jensen & Jensen 1991, Jensen & Iverfeldt 1994, Jensen 1995). Soren Petersen is a biologist specialising in aquatic ecology with special emphasis on environmental impact and fate of toxicants (Petersen & Gustavson 1998, 2000). Jan Ronberg is a chief engineer specialising in sediment transport processes (Ronberg et al 1991, Ronberg et al 1994). And Mads Madson is a senior engineer specializing in development, application and marketing of mathematical modeling systems for simulation of transport dispersion and water quality in rivers and wetlands (Madson et al 1998, Madson et al 1999).

Larry Walker Associates (LWA).

Larry Walker Associates is an environmental engineering, established in 1979, specializing in water quality issues. LWA specializes in water quality regulatory and permit assistance, pollution prevention, water quality monitoring, and stormwater management. In these capacities, LWA has conducted numerous modeling studies of wastewater discharge in the Sacramento-San Joaquin Delta. The company is currently involved in many aspects of the Sacramento River Watershed Program (SRWP), including Hg-related studies. These studies include source identification, establishment of targets, monitoring program setup, and development of a Hg modeling approach to establish a management plan for the watershed. Research and engineering staff likely to work on this project include Brian Laurenson and Jon Ingersoll. Mr. Laurenson is a project engineer with experience in environmental modeling, data analysis, and data management. Mr. Ingersoll is a project scientist who is currently collecting Hg source information for the SRWP.

Technical Advisory Group

Five technical advisors will serve this project. Each will review project plans, help interpret modeling results, and provide guidance to the project. To keep the project current with developing TMDLs, the advisory group will include a representative from each of the two local Water Quality Control Boards. Three other advisors were selected because of their nationally acknowledged level of expertise in fields of research around which this study is based. Dr. Gary Gill is an associate professor of Oceanography at Texas A&M in Galveston. Dr. Gill is a participant in CalFed Grant #99-B06 and specializes in analytic chemistry and biogeochemical cycling of Hg in the environment. Dr. Ray Krone is an internationally recognized expert in cohesive and non-cohesive sediment transport. His early research is the basis for components of many sediment transport models, including the one proposed for this study. Dr. Krone has a long history with sediment issues in the Bay and Delta. Dr. Rob Mason is a chemical oceanographer and associate professor at Chesapeake Bay Biological Laboratory. He has 14 years of Hg research experience with a current focus on factors influencing Hg bioavailability and bioaccumulation by benthic and pelagic organisms. Dr. Mason's model of biouptake will be used in the second part of this proposed study.

F. Cost

F.1. Budget. The cost of this request to develop sediment and Hg models for the Sacramento-San Joaquin Delta is estimated as $525,000. Cost sharing will offset $133,000, so funds requested from CalFed are $392,000. The overall budget for modeling support to the project includes data acquisition and analysis, setup and calibration of already developed hydrodynamic and sediment transport models, incorporation of Hg modeling routines, setup and calibration of Hg models, application of models, analysis of model results, reporting, and project management. A budget summary is provided in Table 1. A summary of tasks and justification is provided in Table 2.

Besides subcontractors and technical advisors, three individuals are expected to be employed on the project. Initial pay scales for these LWA employees range from $18 to $26/hour. Second year salaries reflect a 5% cost-of-living increase. Time commitments for these employees range from 15% to 65% over the span of the project. Salaries and time commitments are presented in Table 3. The benefit-to-salary ratio depends on whether annual bonuses are counted as benefits or as salary. If bonuses are included in benefits, the ratio is about 69%. If bonuses are included in salaries, the ratio is about 42%. LWA practice is to include benefits and bonuses in overhead rates. Overhead charges also include administrative staff, fringe benefits, indirect labor, rent, utilities, telephone, maintenance, indirect travel, supplies, miscellaneous printing & mail, publications, software, education, insurance, and depreciation on equipment and furniture.

Besides salaries, other significant costs include equipment, supplies, and subcontracts. Generally, the only equipment required will be a good PC with a large screen to view graphical displays. Significant supplies for the project include the software packages from the Danish Hydraulics Institute (DHI) that will be used to simulate hydrodynamics, sediment transport, and heavy metals. Although included as a part of this project budget, all software-related fees will be waived by DHI as part of their cost-sharing contribution. Included in these software costs are fees for two-dimensional modeling that is only under consideration for limited use at this time. Two-dimensional modeling is included here because it allows the project more options in implementation and does not represent a cost to CalFed. To ensure proper use of these sophisticated models, the DHI requires users to take a training course, included in the cost of their subcontract. The cost of this proposal includes a two-year support contract. Printing and postage of significant reports are also included in supplies.

The DHI models were chosen for this application because they are well-established models, have a proven record in sediment transport simulation, and incorporate useful user interfaces that produce a wide variety of graphical output (including animations). Although other hydrodynamic models of the Delta exist, none have been incorporated into a Delta-wide sediment transport model. Furthermore, none are as well documented and well supported as the DHI models, which have been extensively used in worldwide applications.

The DHI has been invited to participate because they have a strong staff of technically competent engineers and scientists skilled at setting up and applying the chosen modeling system. Their expertise is necessary to incorporate the needed Hg routines. Once the models are set up, anyone familiar with hydrodynamic and water quality modeling will be able to apply them.

A small amount of funding is requested for travel. There are three categories of travel. Each of us working on modeling the Delta will need to make site visits to see the Delta and understand the kind of assumptions being made and their significance. Additionally, there will be need to travel to local meeting to participate in the active local dialogue on Hg. Finally, the project

proposes to send a representative to the 2001 International Conference on Hg as a Global Contaminant. This biennial conference generally gathers many international researchers associated with Hg fate, transport, and contamination. Information from meeting presentations and discussion will be valuable to the project.

F.2. Cost-Sharing. This project will share costs with several programs and entities within the region. Specifically, a great deal of data will be collected in support of this project by other CalFed projects (Stevenson et al 1999, Schoelhammer and Dinehart 1997, Suchanek and Slotton 1997), the San Francisco Estuary Institute (SFEI), Sacramento River Watershed Program (SRWP), and local Regional Water Quality Control Boards. The value of this information is difficult to estimate, but the funding for these Hg monitoring and research programs exceeds $4,000,000. In addition, UC Davis has agreed to analyze a limited number of water samples for Hg and MeHg as needed to support modeling assumptions, calibrate, or test results (Slotton 2000).

Direct cost sharing in the form of software, technical support, and funding will come from the Danish Hydraulics Institute's research program and the SRWP. Technical support and *software* costs of $93,000 have been offered by Danish Hydraulics Institute to offset the high cost of modifying standard hydrodynamic and water quality models to support Hg modeling. Direct funding of $40,000 to help develop the model will be provided by the SRWP, which includes the Delta in its purview and has an interest in developing a Hg model for its management plans. Cost-sharing contributions to this project total $133,000. Direct cost-sharing support is presented in Table 4.

G. Local Involvement. This modeling project is being coordinated with a number of local groups and agencies concerned with Hg contamination and exposure. The idea for this project derived from discussion with several of these agencies including the San Francisco Bay Area and Central Valley Regional Water Quality Control Boards, the US EPA Superfund Group at Clear Lake, and the Delta Tributaries Mercury Council of the Sacramento River Watershed Program.

Because of the anticipated degree of coordination with planned Hg modeling program in the SF Bay and the Sacramento River watershed, the proposed project will maintain contact with these and other interested parties throughout its execution. At the end of each of the project's two years, modeling results and observations will be presented to both the San Francisco Bay and the Delta Tributaries Hg Councils in a formal presentation.

H. Compliance with Standard Terms and Conditions. The applicant has reviewed the state and federal terms contained in Attachments D and E and agrees to abide by them.

I. Literature Cited

Abu-Saba, K. (2000) "Commitmentto collaborate on proposed Delta Hg Modeling study." Personal communication. San Francisco Bay Area Regional Water Quality Control Board.

Arizona Department of Environmental Quality, U.S. EPA Region 9, and Tetra Tech, I. (1999). "Total Maximum Daily Load and Implementation Plan for Mercury: Pena Blanca Lake, Arizona." , Arizona Department of Environmental Quality, October 15, 1999, 69.

Bale, A. (1997). "BioUptake: A Toxicant Uptake and Bioaccumulation Model." Chapter 11 in: The Role of Sulphur Bank Mine in Mercury Dynamics within Clear Lake, prepared by Tom Suchanek et al. for U.S EPA Region IX Superfund Program. Divisionof Environmental Studies, Univ. of Calif.-Davis, 201-203 and Attachment.

Bale, A. E. (1995). "Modeling Mercury Transport and Transformation in the Aquatic Environment," Ph.D., University of California at Davis.

Bale, A. E. (2000). "Modeling Mercury Fate in Clear Lake, CA." *J. Environ. Engin.*, 126(2), 153-163.

Bloom, N. B. (1992). "On the chemical form of mercury in the edible fish and marine invertebrate tissue." *J Fish Aquatic Sci*, 49, 1010-1017.

Brown, D. S., and J.D. Allison. (1987). "MINTEQA1, An Equilibrium Metal Speciation Model User's Manual." *EPA/600/3-87/012*

DWR (1997) Preliminary Delta Simulation Model Studies of CALFED Delta Conveyance Components. Delta Modeling Section, DWR Modeling Support Branch

Fairey, R., K. Taberski, S. Lamerdin, E. Johnson, R.P. Clark, J.W. Downing, J. Newman and M. Petreas. 1997. Organochlorines and other environmental contaminants in muscle tissues of sportfish collected from San Francisco Bay. Marine Pollution Bulletin 34(12): 1058-1071.

Gill, G. A., N. S. Bloom, S. Cappellino, C. T. Driscoll, C. Dobbs, L. McShea, R. Mason, and J. Rudd (1999). Sediment-Water Fluxes of Mercury in Lavaca Bay, Texas. *Environmental Science nnd Technology*, 33, pp 663-669.

Hudson, R. J. M., Gherini, S. A., Watras, C. J., and Porcella, D. B. (1994). "Modeling the Biogeochemical Cycle of Mercury in Lakes: The Mercury Cycling Model (MCM) and its Application to the MTL Study Lakes." Mercury Pollution: integration and synthesis, C. J. Watras and J. W. Huckabee, eds., Lewis Publishers, 473-523.

Jensen, A. & Iverfeldt, A. (1994). Atmospheric bulk deposition of Mercury to the Southern Baltic Sea Area. Presented at the International Conference on Mercury as a Global Pollutant. Monterey, May 31 -June 4,1992. In: Mercury Pollution: Integration and Synthesis. (Eds. Watras, C. and Hucabee, J.). Lewis Publishers, Boca Raton, Fl, 221-229.

Jensen, A. (1995) Risk Reduction Monograph no. 4 Mercury. Background and National Experience of Reducing Risk. OECD Environmental Monograph Series 103,159 pp.

Jensen, Anders and Jensen, Arne (1991) Historical deposition rates of mercury in Scandinavia estimated by dating and measurement of mercury in cores of peat bogs. Paper presented at International Conference on Mercury as an Environmental Pollutant, Gavle June 11-131990. Published in: Water, Air and Soil Pollution, 1991, 6, 769-777.

Karkowski, J. (2000) "Commitmentto collaborate on proposed Delta Hg Modeling study." Personal communication. Central Valley Regional Water Quality Control Board. and San Francisco Bay Area

Keating, M. H., Mahaffey, K. R., Schoeny, R., Rice, G. E., Bullock, O. R., Ambrose, R. B., Swartout, J., and Nichols, J. W. (1997). "Mercury Study Report to Congress." *EPA-452/R-97-003*, December, 1997,.

Krone, R. B. (1962). "Flume Studies of the Transport of Sediment in Estuarial Shoaling Processes." Hydraulic Engineering Laboratory, University of California-Berkeley

Madsen **Mads** N., Jesper Dørge, Bogdan Oldakowski, Krystian Piechowiak Assessment and minimisation of environmental impacts of a planned reservoir using an integrated modelling approach. Modelling, Testing & Monitoring for Hydro Powerplants-III, Aix-en Provence, France, Oct. 1998.

Madsen Mads N, La Quian-Ming, Karsten Havnø, Henrik Larsen: The role of mathematical models during strategy formulation for water resources and waste water management in the Sichuan Province, China. International Conference on Water Environment, Ecology, Socio-Economics and Health Engineering, Oct. 1999.

Martin, J. L. (1992). "MERC4: A Mercury Transport and Kinetics Model (Beta Test Version 1.0). Model Theory and User's Guide."

Mason, **R** P. "Consideration of benthic uptake routes." Personal email communication. Chesapeake Bay Biological Laboratory.

Mason, R P., Fitzgerald, **W.** F., Hurley, J., Hanson, A. K., Jr., Donaghay, P. L., and Sieburth, J. M. (1993). "Mercury biogeochemical cycling in a stratified estuary." *Limnol. Oceanogr.*, 38(6), 1227-1241.

Mason, R P., Reinfelder, J. R, and Morel, F. M. M. (1995). "Bioaccumulation of mercury and methylmercury." *Water, Air, and Soil Pollut.*, 80, 915-921.

Mason, R. P., Reinfelder, J. R., and Morel, F. M. M. (1996). "Uptake, toxicity, and trophic transfer of mercury **in** a coastal diatom." *Environmental Science and Technology*, 30(6), 1835-1845.

Mason, R. P., Reinfelder, J., and Morel, F. M. (1995a). "The Accumulation, Toxicity, and Trophic Transfer of Methylmercury." *Enviro. Sci. Technol.*

Petersen S. and K. Gustavson (2000) Toxic effects of TBT on natural enclosed phytoplankton at ambient TBT concentrations of coastal water. Ecotoxicology in press

Petersen, S. and K. Gustavson (1998). Toxic effects of Tri-Butyl-Tin (TBT) on autotrophic pico-, nano- and microplankton assessed by a size fractionated pollution induced community tolerance (SF-PICT) concept, Aquatic Toxicology 40253-264.

PTI Environmental Services. (1997). "Onondaga Lake RI/FS Mercury Modeling Report." *PTI contract #CB50*, Allied Signal Inc., Solvay, NY, 6/97, .

RMA (1999) Mathematical Modeling of Hydrodynamics and Water Quality Impacts of Suisun Marsh Levee Breaches.

Rønberg, J.K., Hedegaard, LB., and Deigaard, R.: Cross-shore sediment transport, including long-period effects. MAST G8, Gregynog Workshop, Wales, U.K., 1994.

Rønberg, J.K., Hedegaard, LB., and Deigaard, R.: Sensitivity of Cross-shore and longshore transport, Part 1+ Part 2. MAST G6M Midterm Conference, Edinburgh, U.K., 1991.

Schoellhammer, D. and R.L. Dinehart (1999) "Sedimentation in the Delta of the Sacramento and San Joaquin Rivers, CA." CALFED Contract No. 97-BO2. USGS

SFEI. 1999. Contaminant Concentrations **in Fish** from San Francisco Bay, 1997. San Francisco Estuary Institute, Richmond, CA.

Slotton, D. (2000) "Commitment to analyze limited set of water samples in support of proposed Delta Hg Modeling study." Personal communication. Univ. of CA. at Davis.

Stephenson, M., and et **al.** (1999). **"An** Assessment of Ecological and Human Health Impacts of Mercury in the San Francisco Bay-Delta Watershed." CALFED Contract No. 99-B06. Dept. of Fish and Game

Suchanek, T.H. and D.G. Slotton (1999) "Effects of Wetland Restoration on the Production of Methyl Mercury in the San Francisco Bay-Delta System." CALFED Contract No. 97-C05 . University of California, Davis

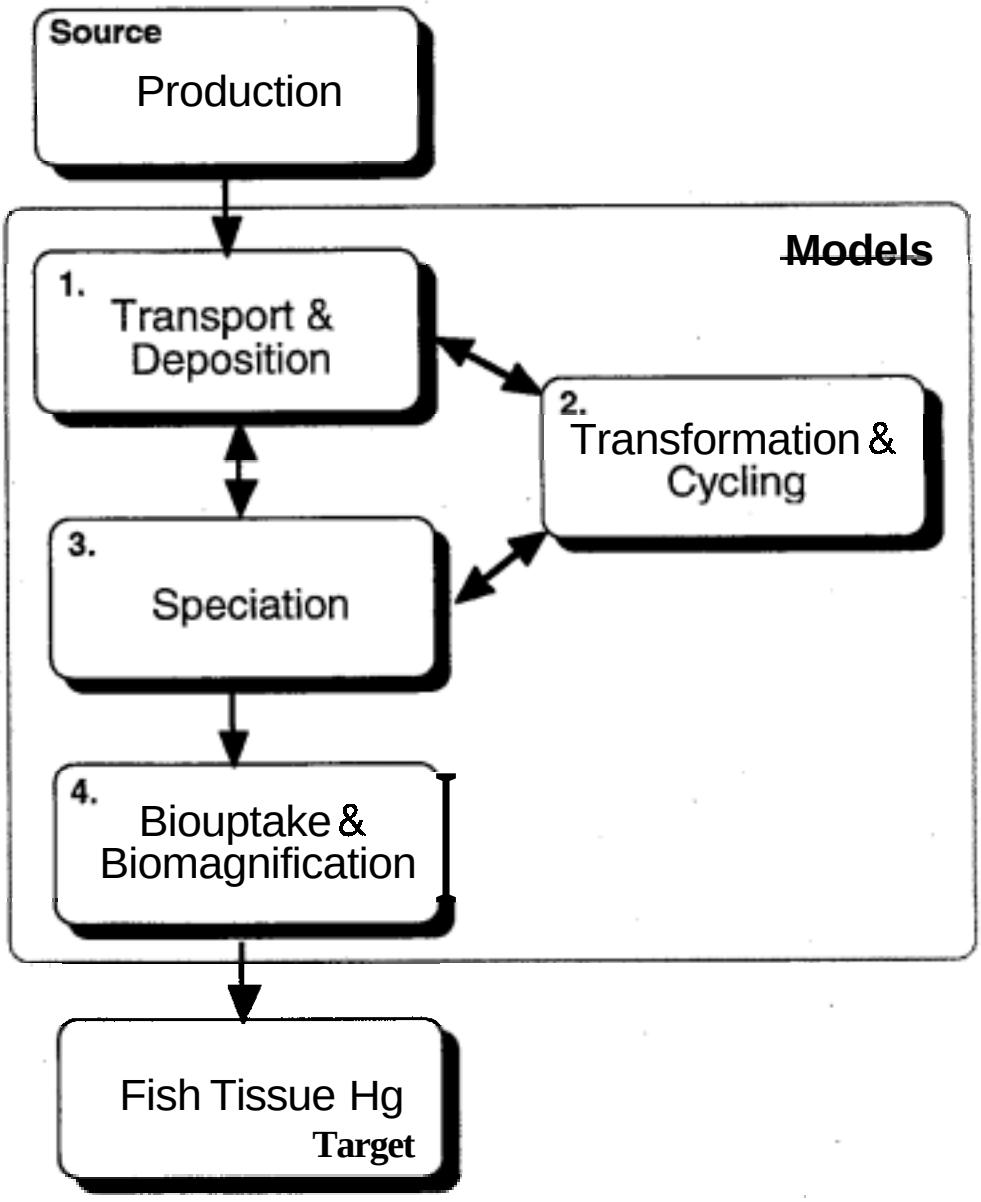


Figure 1. Connection between Hg source, models, and regulatory targets

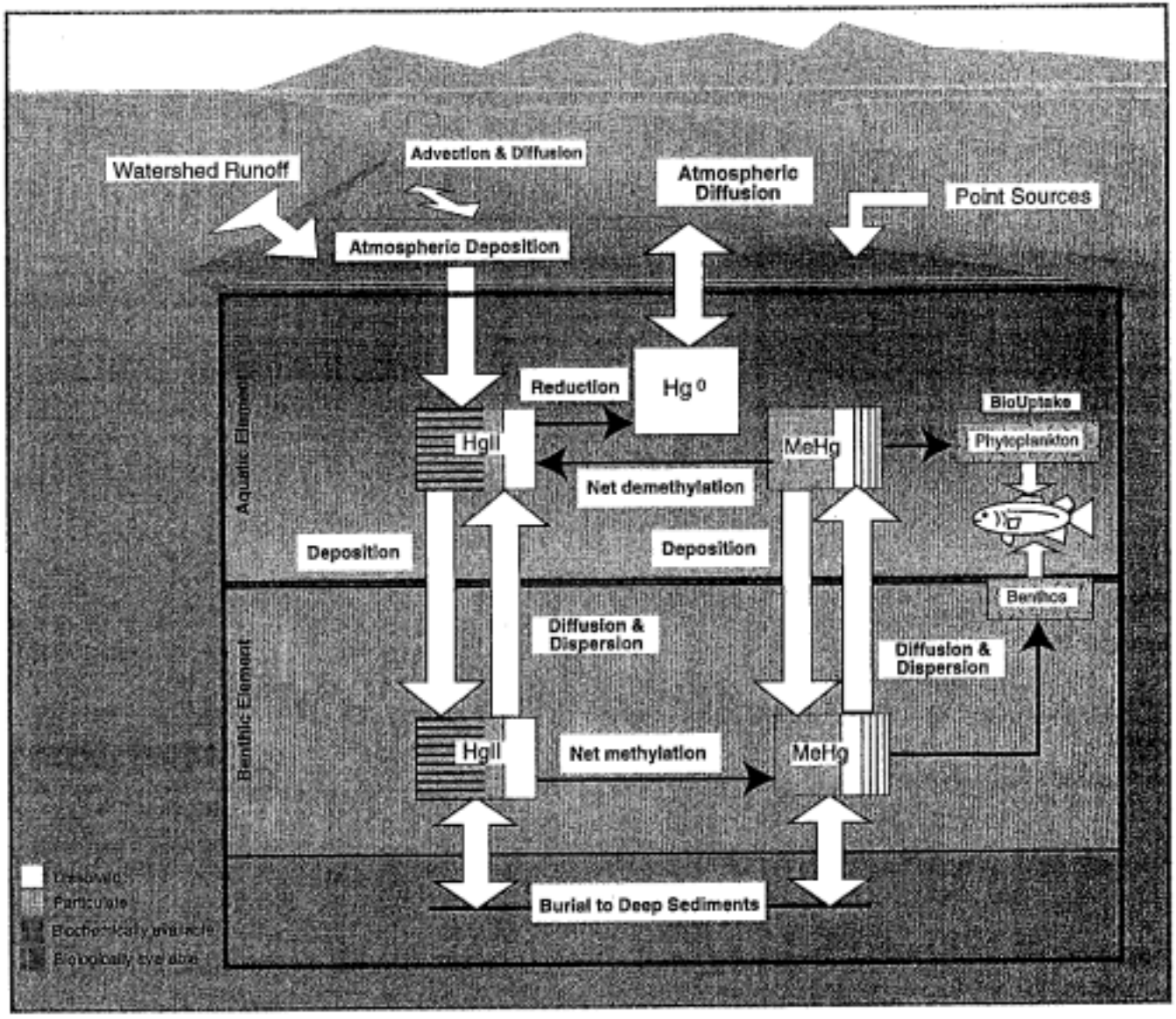


Figure 2. Schematic of Hg Fate and Transport in a Watershed

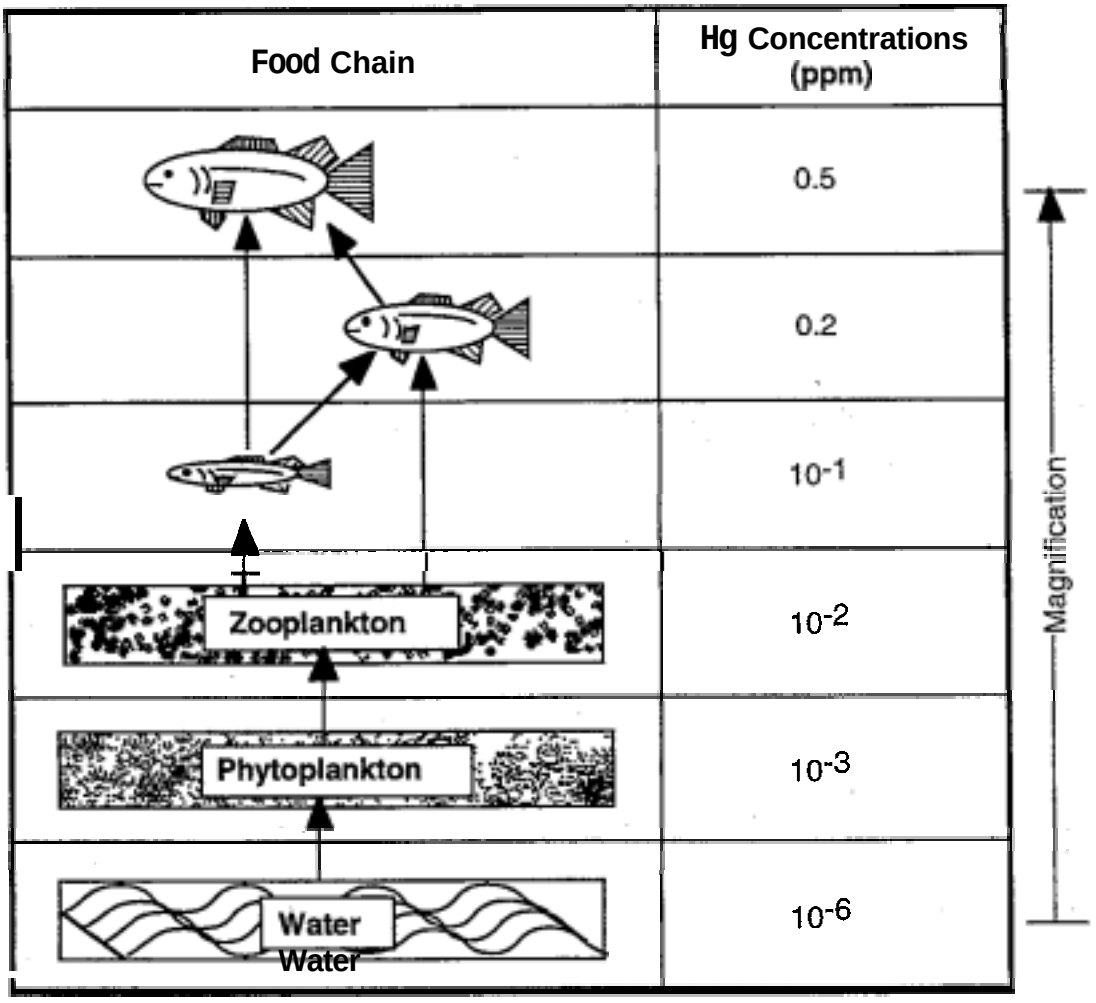


Figure 3. Magnification of Hg in Hypothetical Food Chain

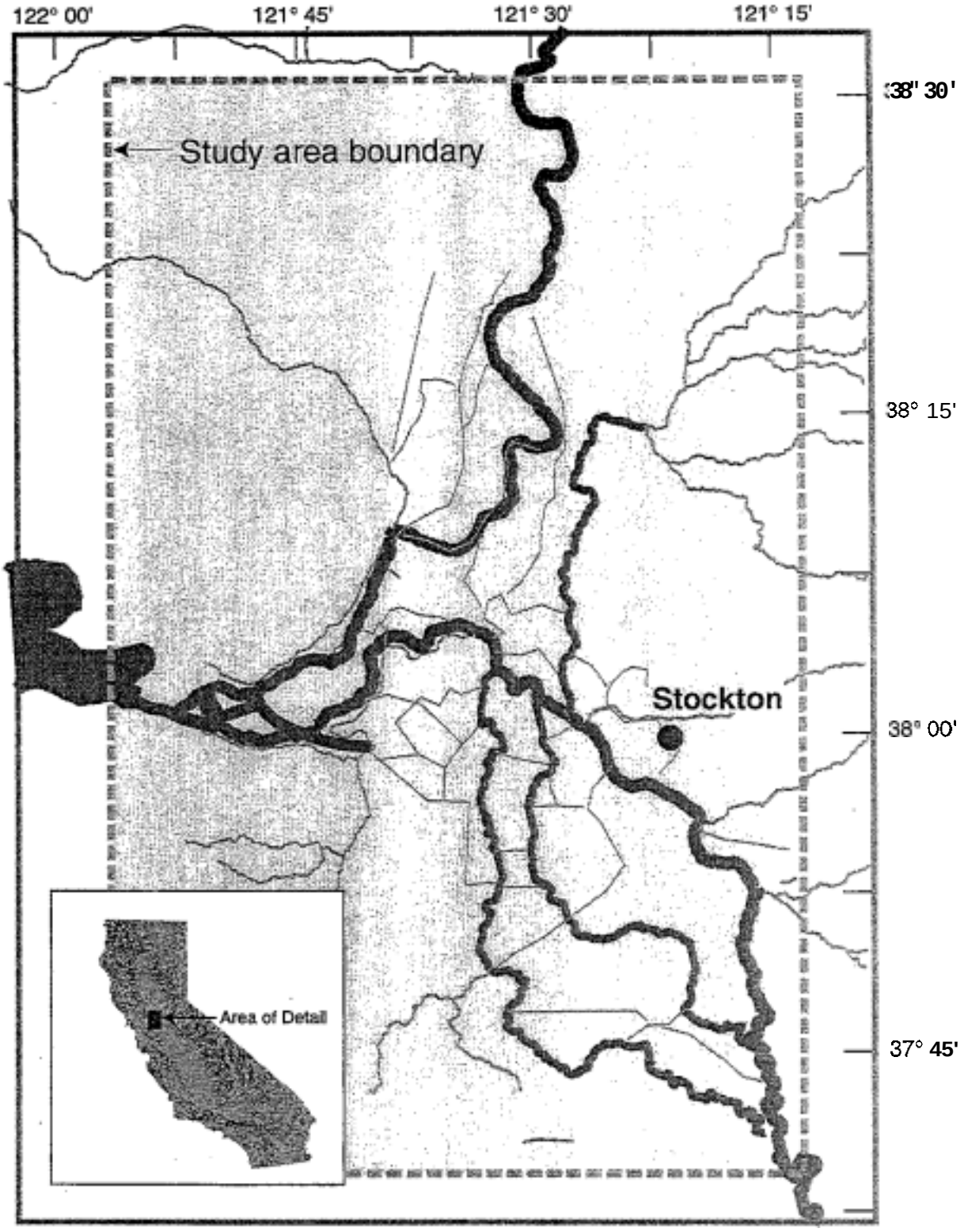


Figure 4. Location of study area

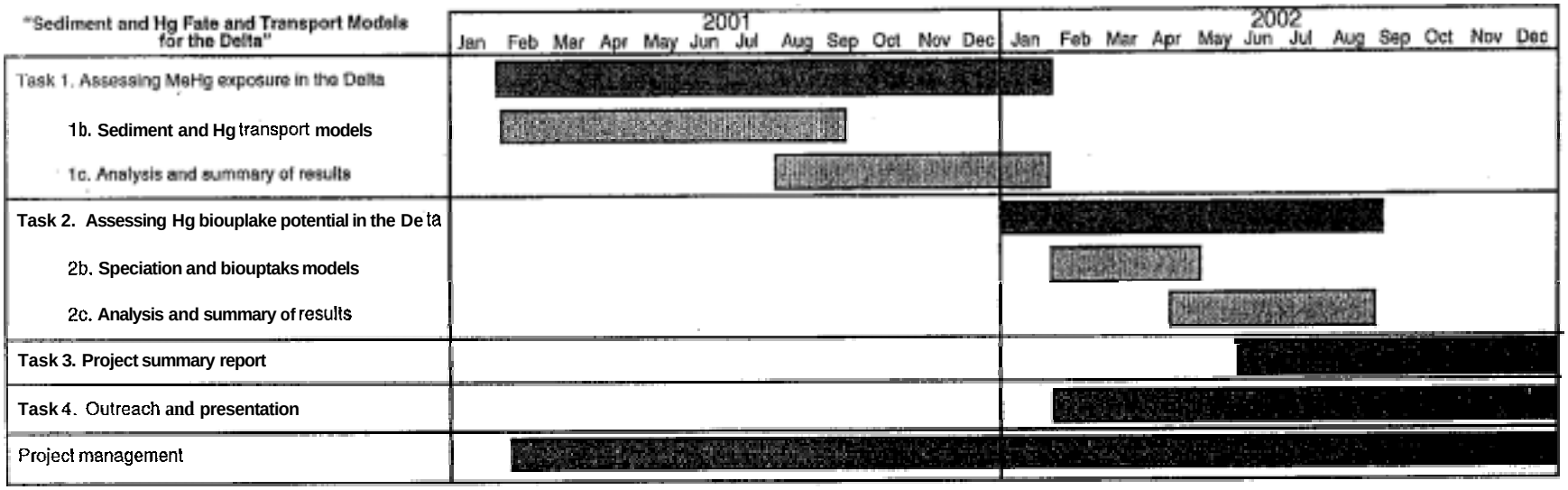


Figure 5. Timeline

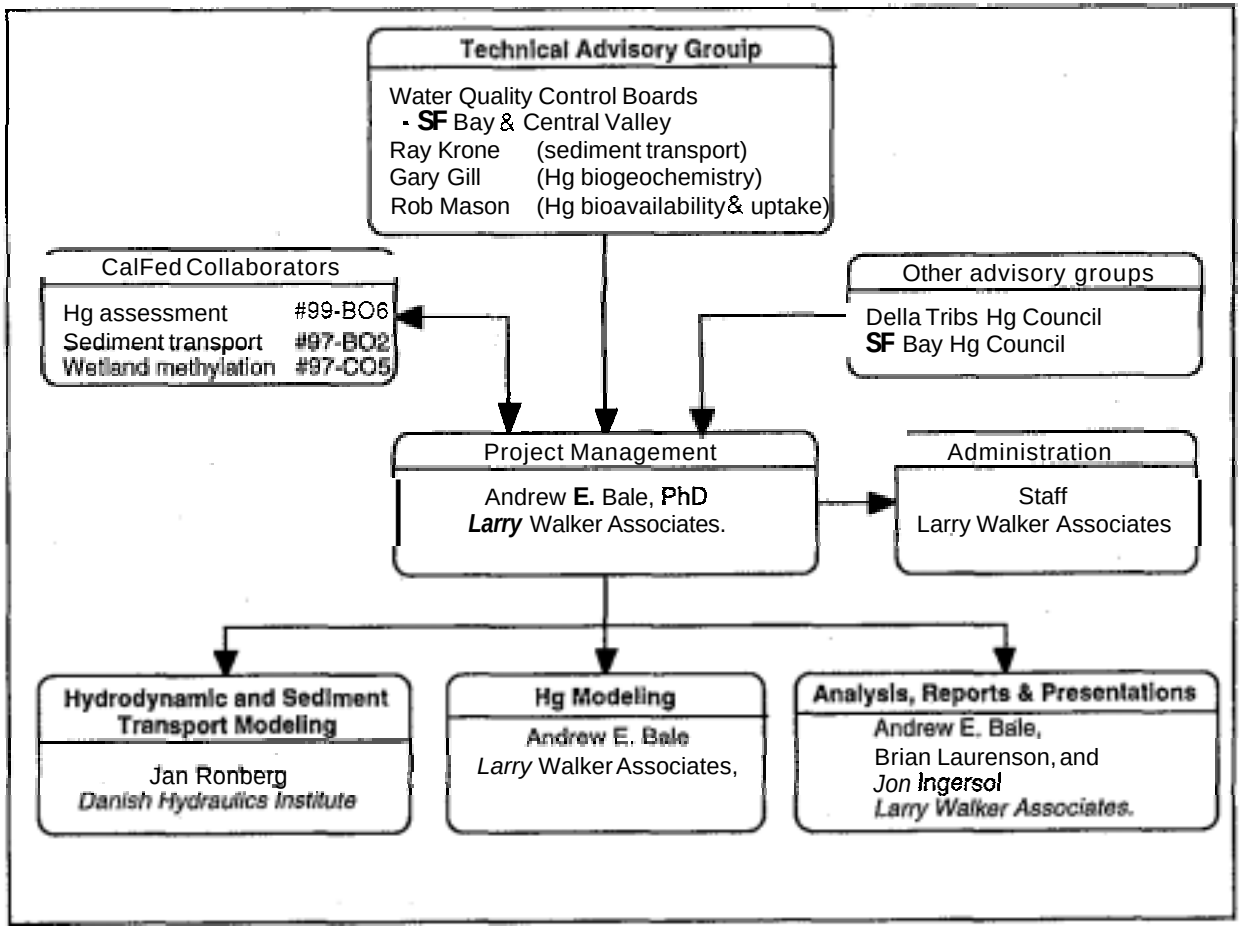


Figure 6. Organizational Chart

Table 1. Budget Summary

Table 1. Annual and total budget.

Year	Task	Direct Labor Hours	Salary	Overhead* (184%)	Fee (15%)	Travel	Not subject to overhead: Supplies & Expendables	Not subject to overhead: Equipment	Not subject to overhead: Service Contracts**	Total Cost
Year 1	Task 1									
	Subtask 1a	700	$17,422	$32,056	$7,422	$900	$55,425	$3,400	$130,500	$247,124
	Subtask Ib	630	$14,837	$27,300	$6,320		$800			$49,257
	Project Management	200	$5,326	$9,799	$2,269	$2,000				$19,393
Total Cost Year 1			$37,584	$69,155	$16,011	$2,900	$56,225	$3,400	$130,500	$315,774
Year 2	Task 2									
	Subtask 2a	560	$14,634	$26,927	$6,234	$2,100	$0	$0	$35,900	$85,795
	Subtask 2b	560	$14,378	$26,456	$6,125	$0	$500	$E	$0	$47,460
	Task 3	700	$17,014	$31,305	$7,246	$1,200	$1,100	$0	$0	$57,867
	Project Management	200	$5,592	$10,289	$2,362	$0	$0	$0	$0	$18,263
Total Cost Year 2			$51,616	$94.977	$21,989	$3,300	$1,600	$0	$35,900	$209.385
Total Project Cost			$89,202	$164,132	$38,000	$6,200	$57.825	$3,400	$166,400	$525.159
									Cost share:	$133,125
									CalFed:	$392,034

* applies only to salary

** service contract fees include actual expense **plus** 10%profit

Table 2. Summary of tasks and justification

Task	Description	Justification
1	Assessing Delta MeHg exposure levels	Estimate distribution of sediments and Hg from sources to locations throughout Delta and resulting MeHg exposure levels.
1a	***Sediment and Hg transport and fate models***	• Compile available data • Set-up and calibrate: Model of Delta hydrodynamics Model of sediment transport Model of Hg fate & transport in the Delta
1b	***Analysis and summary of results***	• Sensitivity analysis of key parameters • Identify potential "hot spots" • Compare management scenario results • Discuss and recommend further research
2	Assessing Delta Hg biouptake potential	Estimate Hg fish tissue levels under various management scenarios.
2a	***Speciation and biouptake model***	• Compile of available data • Develop Hg speciation and trophic transfer models • Link site-specific Hg speciation and trophic transfer models to fate & transport model
2b	*Analysis* ***and summary of results***	• Sensitivity analysis of key parameters • Identify potential "hot spots" • Compare management scenario results • Discuss and recommend further research
3	Project *summary* report & presentation	• Summarize research results including final model of system and recommendations. • Present results in various local and national forums.
	Project management	• Overall coordination, organization, and scheduling. • Final model verification & validation. • Supervise reporting.

Table 3. Salaries and time commitments

Name	Position	Pay rate ($/hr)	Time commitment (%)	
			Year 1	Year 2
Andy Bale	Project manager	26.63	50%	65%
Brian Laurenson	Project engineer	22.90	15%	20%
Jon Ingersoll	Project scientist	18.18	15%	20%

Table 4. Cost Sharing

Type of support	Program	Estimated value
Technical support	DHI	$29,700
Software, maintenance, & training	DHI	$63,400
Direct support	SRWP	$40,000
	Total:	$133,100

509 4th Street
Davis. CA 95616

530.753.6400
530.753.7030 fax

www.lwadavis.com

LARRY WALKER ASSOCIATES

Letters of Notification.

DATE May 14,2000

TO: CalFed Bay-Delta Program

FROM Andrew E. Bale
Larry Walker Associates

SUBJECT: Exemption from public notification requirement.

The proposed project "Sediment and Hg Fate and Transport Models to Guide Monitoring and Management Plans in the Delta" is considered exempt from all public notification requirements because the project does not contain any potential construction or restoration actions. This project, which proposes to develop and apply numerical models based on data collected by others, is a research project conducted solely in the laboratory and office.

With any questions regarding'this declaration, please contact me by telephone at (530) 753-6400 x30 or, by email at andyb@lwadavis.com.

Sincerely,

Andrew E. Bale
Project manager

Environmental Compliance Checklist

All applicants must fill out *this* Environmental Compliance *Checklist.* Applications must contain answers to the following questions to be *responsive* and *to* be considered for funding. *Failure to answer these questions and include them with the application will result in the application being considered nonresponsive and not considered for funding.*

1. Do any of the actions included in the proposal require compliance with either the California Environmental Quality Act (CEQA), the National Environmental Policy Act (NEPA), or both?

   _____ YES X NO

2. If you answered yes *to* # 1, identify the lead governmental agency for CEQA/NEPA compliance.

   _____
   Lead Agency

3. If you answered no to # 1, explain why CEQA/NEPA compliance is not required for the actions in the proposal.

   Compliance is not required because proposal contains nothing that would directly impact environmental quality. Proposal is solely for research that will develop and apply numerical models.

4. IF CEQA/NEPA compliance is required, describe how the project will comply with either or both of these laws. Describe where the project is in the compliance process and the expected date of completion.

5. Will the applicant require access across public or private property *that* the applicant does not own to accomplish the activities In the proposal?

   _____ YES X NO

   IF yes, the applicant must attach written permission for access from the relevant property owner(s). Failure to iodude written permission for access may result In disqualification *of* the proposal during the review process. Research and monitoring Field projects for which specific field locations have not been identified will be required *to* provide access needs and permission for access with M days *of* notification of approval.

Land Use Checklist

All applicants must fill *out* this Land Use Checklist for their proposal. Applications must contain answers to the following questions to be responsive and to be considered for funding. *Failure to answer these questions and include them with the application will result in the application being considered nonresponsive and not considered for funding.*

1. Do the actions in the proposal involve physical changes to the land(i.e. grading, planting vegetation, or breeching levees) or restrictions in land use (i.e. conservation easement or placement of land in a wildlife refuge)?

   _____ YES X NO

2. UNO to # *1,* explain what type of actions are involved in (be proposal (i.e., research only, planning only).

   Proposal involves research developing and applying numerical models only.

3. If YES to # 1 what h the proposed land use change or restriction under the proposal?

4. If YES to # 1, is the land currently under a Williamson Act contract?

   _____ YES _____ NO

5. If YES to # 1, answer the following:

   Current land use _____
   Current zoning _____
   Current general plan designation _____

6. If YES to #1, is the land classified as Prime Farmland, Farmland of Statewide Importance or Unique Farmland on the Department of Conservation Important Farmland Maps?

   _____ YES _____ NO _____ DON'T KNOW

7. If YES to # 1, how many acres of land will be subject to physical change or land use restrictions under the proposal?

   _____

8. If YES to # 1, is the property currently being commercially farmed or grazed?

   _____ YES _____ NO

9. If YES to #8, what are the number of employees/acre_____
   the total number of employees _____

STATE OF CALIFORNIA

NONDISCRIMINATION COMPLIANCE STATEMENT

STD. 19 (REV. 3-95)

COMPANY NAME

The company named above (herinafter referred to as "prospective contractor") hereby certifies, unless specifically exempted, compliance with Government Code Section 12990 (a-f) and California Code of Regulations, Title 2, Division 4, Chapter 5 in matters relating to reporting requirements and the development, implementation and maintenance of a Nondiscrimination Program. Prospective contractor agrees not to unlawfully discriminate, harass or allow harassment against any employee or applicant for employment because of sex, race, color, ancestry, religious creed, national origin, physical disability (including HIV and AIDS), medical condition (cancer), age (over 40), marital status, denial of family care leave and denial of pregnancy disability leave.

CERTIFICATION

I, the official named below, hereby swear that I am duly authorized to legally bind the prospective contractor to the above described certification. I am fully aware that this certification, executed on the date and in the county below, is made under penalty of perjury under the laws of the State of California.

OFFICIAL'S NAME
Larry F. Walker

DATE EXECUTED
5/15/00

EXECUTED IN THE COUNTY OF
Yolo

PROSPECTIVE CONTRACTOR'S SIGNATURE
Larry F. Walker

PROSPECTIVE CONTRACTOR'S TITLE
President

PROSPECTIVE CONTRACTORS LEGAL BUSINESS NAME
Larry Walker Associates

APPLICATION FOR FEDERAL ASSISTANCE

OMB Approval No. 0348-0043

1. TYPE OF SUBMISSION Application: ☐ Construction ☒ Non-Construction Preapplication: ☐ construction ☐ Non-Construction	2. DATE SUBMITTED: 5/15/00 3. DATE RECEIVED BY STATE 4. DATE RECEIVED BY FEDERAL AGENCY	Applicant Identifier State Application Identifier Federal Identifier

5. APPLICANT INFORMATION

Legal Name: Larry Walker Associates	Organizational Unit:
Address *(give city, county,* State, *and zip mde):* 509 4th St., Davis, CA. 95616	Name and telephone number of person to be contacted on matters involving this application *(give area code)*: Andy Bale (530) 753-6400 x30
6. EMPLOYER IDENTIFICATION NUMBER *(EIN):* 94-2610668	7. TYPE OF APPLICANT: (enter appropriate *letter in box)*: M A. State; B. County; C. Municipal; D. Township; E. Interstate; F. Intermunicipal; G. Special District; H. Independent School Dist.; I. State Controlled Institution of Higher Learning; J. Private University; K. Indian Tribe; L. individual; M. Profit Organization; N. Other (Specify)
8. TYPE OF APPLICATION ☐ New ☐ continuation ☐ Revision If Revision, enter appropriate letter(s) in box(es) ☐ ☐ A. Increase Award B. Decrease Award C. Increase Duration D. Decrease Duration Other(specify):	9. NAME OF FEDERAL AGENCY: CalFed
10. CATALOG OF FEDERAL DOMESTIC ASSISTANCE NUMBER: ☐☐-☐☐☐ TITLE:	11. DESCRIPTIVE TITLE OF APPLICANTS PROJECT: Sediment & Hg Fate ad Transport Models *to* Guide Monitory ad Management Plans in rhe Delta
12. AREAS AFFECTED BY PROJECT *(Cities,* Counties, States. *etc.)*: None	
13. PROPOSED PROJECT: Numerical Model	14. CONGRESSIONAL DISTRICTS OF: Congressional District 3
Start Date: 7/01 Ending Date: 12/02	a. Applicant: Andrew E. Bale b. Project: Sediment & Hg Models for the Delta

15. ESTIMATED FUNDING

a. Federal	$ 392,000
b. Applicant	$
c. State	$
d. Local	$ 40,000
e. Other	$ 93,000
f. Program Income	$
g. TOTAL	$ 525,000

16. IS APPLICATION SUBJECT TO REVIEW BY STATE EXECUTIVE ORDER 12372 PROCESS?

a. YES. THIS PREAPPLICATION/APPLICATION WAS MADE AVAILABLE TO THE STATE EXECUTIVE ORDER 12372 PROCESS FOR REVIEW ON: DATE _____

b. No. ☐ PROGRAM IS NOT COVERED BY E. O. 12372
☐ OR PROGRAM HAS NOT BEEN SELECTED BY STATE FOR REVIEW

17. IS THE APPLICANT DELINQUENT ON ANY FEDERAL DEBT?

☐ Yes If Yes attach an explanation. ☒ No

18. TO THE BEST OF MY KNOWLEDGE AND BELIEF, ALL DATA IN THIS APPLICATION/PREAPPLICATION ARE TRUE AND CORRECT, THE DOCUMENT HAS BEEN DULY AUTHORIZED BY THE GOVERNING BODY OF THE APPLICANT AND THE APPLICANT WILL COMPLY WITH THE ATTACHED ASSURANCES IF THE ASSISTANCE IS AWARDED.

a. Type Name of Authorized Representative: Tom Grovhoug	b. Title: Vice President	c. Telephone Number: (530) 753-6400 x14
d. Signature of Authorized Representative: Tom Grovhoug		e. Date Signed: 5/15/00

Previous Edition Usable
Authorized for Local Reproduction

Standard Form 424 (Rev. 7-97)
Prescribed by OMB Circular A-102

OMB Approval No. 0348-0044

BUDGET INFORMATION - Non-Construction Programs

SECTION A - BUDGET SUMMARY

Grant Program Function or Activity (a)	Catalog of Federal Domestic Assistance Number (b)	Estimated Unobligated Funds		New or Revised Budget		
		Federal (c)	Non-Federal (d)	Federal (e)	Non-Federal (f)	Total (g)
1.		$	$	$ 392,000	$ 133,000	$ 525,000
2.						
3.						
4.						
5. Totals		$	$	$	$	$

SECTION B - BUDGET CATEGORIES

6. Object Class Categories	GRANT PROGRAM, FUNCTION OR ACTIVITY (1)	(2)	(3)	(4)	Total (5)
a. Personnel	$ 89,200	$	$	$	$
b. Fringe Benefits	62,000				
c. Travel	6,200				
d. Equipment	3,400				
e. Supplies	57,600				
f. Contractual	166,400				
g. Construction	-				
h. Other					
i. Total Direct Charges *(sum of 6a-6h)*	384,400				
j. Indirect Charges	140,600				
k. TOTALS *(sum of 6i and 6j)*	$ 525,000	$	$	$	$
7. Program Income	$ ø	$	$	$	$

Authorized for Local Reproduction

Standard Form 424A (Rev. 7-97)
Prescribed by OMB Circular A-102

Previous Edition Usable

*Note: Fee included with overhead in indirect costs

OMB Approval No. 0348-0040

ASSURANCES - NON-CONSTRUCTION PROGRAMS

Public reporting burden for this collection of information is estimated to average 15 minutes per response, including time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding the burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to the Office of Management and Budget, Paperwork Reduction Project (0348-0040), Washington, DC 20503.

PLEASE DO NOT RETURN YOUR COMPLETED FORM TO THE OFFICE OF MANAGEMENT AND BUDGET. SEND IT TO THE ADDRESS PROVIDED BY THE SPONSORING AGENCY.

NOTE Certain of these assurances may not be applicable to your project or program. If you have questions, please contact the awarding agency. Further, certain Federal awarding agencies may require applicants to certify to additional assurances. If such is the case, you will be notified.

As the duly authorized representatie of the applicant, I certify that the applicant:

1. Has the legal authority *to* apply for Federal assistance and the institutional. managerial and financial capability (including funds sufficient to pay the non-Federal share of project cost) to ensure proper planning, management and completion of the project described in this application.

2. Will give the awarding agency, the Comptroller General of the United States and, if appropriate, the State, through any authorized representative, access to and the right to examine all records, books, papers, or documents related to Me award; and will establish a proper accounting system in accordance with generally accepted accounting standards or agency directives.

3. Will establish safeguards'to prohibit employees from using their positions for a purpose that constitutes or presents the appearance of personal or organizational conflict of interest, or personal gain.

4. Will initiate and complete the work within the applicable time frame after receipt of approval of the awarding agency.

5. Will comply with the Intergovernmental Personnel Act of 1970 (42 U.S.C. §§4728-4763) relating to prescribed standards for merit systems for programs funded under one of the 19 statutes or regulations specified in Appendix A of OPM's Standards for a Merit System of Personnel Administration (5 C.F.R. 900, Subpart F).

6. Will comply with all Federal statutes relating to nondiscrimination. These include but are not limited to: (a) Title Vi of the Civil Rights Act of 1964 (P.L. 88-352) which prohibits discrimination on the basis of race. color or national origin; (b) Title IX of the Education Amendments of 1972, as amended (20 U.S.C. §§1681-1683, and 1685-1686), which prohibits discrimination on the basis of sex; (c) Section 504 of the Rehabilitation Act of 1973, as amended (29 U.S.C. §794), which prohibits discrimination on the basis of handicaps; (d) the Age Discrimination Act of 1975, as amended (42 U.S.C. §§6101-6107), which prohibits discrimination on the basis of age: (e) the Drug Abuse Office and Treatment Act of 1972 (P.L. 92-255), as amended, relating to nondiscrimination on the basis of drug abuse; (f) the Comprehensive Alcohol Abuse and Alcoholism Prevention, Treatment and Rehabilitation Act of 1970 (P.L. 91-616), as amended, relating to nondiscrimination on the basis of alcohol abuse or alcoholism; (g) §§523 and, 527 of the Public Health Service Act of 1912 (42 U.S.C. §§290 dd-3 and 290 ee 3). as amended, relating to confidentiality of alcohol and drug abuse patient records; (h) Title Vili of the Civil Rights Act of 1968 (42 U.S.C. §§3601 et seq.). as amended, relating to nondiscrimination in the sale, rental or financing of housing: (i) any other nondiscrimination provisions in the specific statute(s) under which application for Federal assistance is being made: and, (j) the requirements of any other nondiscrimination statute(s) which may apply *to* the application.

7. Will comply, or has already complied, with the requirements of Titles Ii and IIl of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 (P.L. 91-646) which provide *for* fair and equitable treatment of persons displaced or whose property is acquired as a result of Federal or federally-assisted programs. These requirements apply to all interests in real property acquired for project purposes regardless of Federal participation in purchases.

8. Will comply, as applicable, with provisions of the Hatch Act (5 U.S.C. §§1501-1508 and 7324-7328) which limit the political activities of employees whose principal employment activities are funded in whole or in part with Federal funds.

U.S. Department **of** the **Interior**

Certifications Regarding Debarment, Suspension and Other Responsibility Matters, Drug-Free Workplace Requirements and Lobbying

Persons signing this form should refer to the regulations referenced below for complete instructions:

Certification Regarding Debarment, Suspension, and Other Responsibility Matters - Primary Covered Transactions - The prospective primary participant further agrees by submitting this proposal that it will Include the clause titled, "Certification Regarding Debarment, Suspension, Ineligibility and Voluntary Exclusion - Lower Tier Covered Transaction," provided by the department or agency entering into this covered transaction, without modification, In all lower tier covered transactions and in all solicitations for lower tier covered transactions. See below for language to be used; use this form for certification and sign; or use Department of the Interior Form 1954 (DI-1954). (See Appendix A of Subpart D of 43 CFR Part 12.)

Certification Regarding Debarment, Suspension, Ineligibility and Voluntary Exclusion - Lower Tier Covered Transactions - (See Appendix B Of Subpart D of 43 CFR Part 12.)

Cetiiication Regarding Drug-Free Workplace Requirements - Alternate I. (Grantees Other Than Individuals) and Alternate II. (Grantees Who are Individuals) - (See Appendix C of Subpart D of 43 CFR Part 12.)

Signature on this form provides for compliance with certification requirements under 43 CFR Parts 12 and 18. The certifications shall be treated as a material representation of fact upon which reliance will be placed when the Department of the Interior determines to award the covered transaction, grant, cooperative agreement or loan.

PARTA Certification Regarding Debarment, Suspension, and Other Responsibility Matters - Primary Covered Transactions

CHECK ✓ IF MIS *CERTIFICATION IS* FORA PRIMARY COVERED *TRANSACTION AND IS* APPLICABLE.

(1) The prospective primary participant certifies to the best of its knowledge and belief, that it and its principals:

(a) Are not presently debarred, suspended, proposed for debarment. declared ineligible, or voluntarily excluded from covered transactions by any Federal department or agency;

(b) Have not within a three-year period preceding this proposal been convicted *of* or had a civil judgment rendered against them for commission of fraud or a criminal offense in connection with obtaining, attempting to obtain, or performing a public (Federal, State or local) transaction or contract under a public transaction; violation of Federal or State antitrust statutes or commission of embezzlement, theft, forgery, bribery, falsification or destruction of records, making false statements, or receiving stolen property:

(c) Are not presently indicted for or otherwise criminally or civilly' charged by a governmental entity (Federal, State or local) with commission of any of the offenses enumerated in paragraph (1)(b) of this certification; and

(d) Have not within a three-year period preceding this applicationlpmposalhad one or more public transactions (Federal, State or local) terminated for cause or default.

(2) Where the prospective primary participant is unable to certify to any of the statements in this certification, such prospective participant shall attach an explanation to this proposal.

PARTB: Certification Regarding Debarment, Suspension, Ineligibility and Voluntary Exclusion - Lower Tier Covered Transactions

CHECK __ IF *THIS* CERTIFICATION IS *FOR A* LOWER TIER *COVERED TRANSACTION* AND IS APPLICABLE.

(1) The prospective lower tier participant certifies, by submission of this proposal, that neither it nor its principals is presently debarred, suspended, proposed for debarment, declared ineligible. or voluntarily excluded from participation in this transaction by any Federal department or agency.

(2) Where the prospective lower tier participant is unable to certify to any of the statements in this certification, such Prospective participant shall attach an explanation to this proposal.

DI-2010
March 1995
(This form consolidates DI-1953, DI-1954 DI-1955. DI-1956 and DI-1963)

PARTE: Certification Regarding Lobbying
Certification for Contracts, Grants, Loans, and Cooperative Agreements

CHECK ✓ IF CERTIFICATION IS FOR THE AWARD OF ANY OF THE FOLLOWING AND THE AMOUNT EXCEEDS $100,000: A FEDERAL GRANTOR COOPERATIVE AGREEMENT, SUBCONTRACT. OR SUBGRANT UNDER THE GRANTOR COOPERATIVE AGREEMENT.

CHECK __ IF CERTIFICATION IS FOR THE AWARD OF A FEDERAL LOAN EXCEEDING THE AMOUNT OF $150,000, OR A SUBGRANT OR SUBCONTRACT EXCEEDING $100,000. UNDER THE LOAN.

The undersigned certifies, to the best of his or her knowledge and belief,,that:

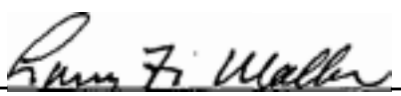
(1) No Federal appropriated funds have been paid or will be paid, by or on behalf of the undersigned, to any person for influencing or attempting to influence an officer or employee of an agency, a Member of Congress, and officer or employee of Congress, or an employee of a Member of Congress in connection with the awarding of any Federal contract, the making of any Federal grant, the making of any Federal loan, the entering into of any cooperative agreement, and the extension, continuation, renewal, amendment, or modification of any Federal contract, grant, loan, or cooperative agreement.

(2) If any funds other than Federal appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with this Federal contract, grant, loan. or cooperative agreement, the undersigned shall complete and submit Standard Form-LLL, "Disclosure Form to Report Lobbying," in accordance with its instructions.

(3) The undersigned shall require that the language of this certification be included in the award documents for all subawards at all tiers (including subcontracts, subgrants, and contracts under grants, loans, and cooperative agreements) and that all subrecipients shall certify accordingly.

This certification is a material representation of fact upon which reliance vias placed when this transaction was made or entered into. Submission of this certification is a prerequisite for making or entering into this transaction imposed by Section 1352, title 31. U.S. Code. Any person who fails to file the required certification shall be subject to a civil penalty of not less than $10,000 and not more than $100.000 for each such failure.

As'the authorized certifying official, I hereby certify that the above specified certifications are true.

SIGNATURE OF AUTHORIZED CERTIFYING OFFICIAL 

TYPED NAME AND TITLE President

DATE 5/15/00

DI-2010

March 1995

(This form consolidates DI-1953, DI-1954, DI-1955, DI-1956 and DI-1963)